2

Basic Concepts in the Organization of Irrigation

Robert Chambers
UNIVERSITY OF SUSSEX

To a remarkable degree, many writers on irrigation ignore and even appear unaware of the relationships between people and irrigation water. Attention is usually fixed on hydrological, engineering, agricultural, and economic aspects. Especially in official documents it is rare to find described, let alone analyzed, the human side of the organization and operation of irrigation systems—the management of those who manage the water, the procedures for irrigation control, the processes of allocation of water to groups or individuals, the distribution of water within groups. There may be almost as many instances of these omissions as there are reports on irrigation.

Thus the report of the working group for the formulation of the Indian Fourth Five-Year Plan proposals on soil and water management under irrigated conditions (ICAR, 1966) is entirely technically oriented, has no place for any social scientist on any research station, and proposes no research on organizational aspects of irrigation or on the management of the staff who manage the water. A report of an irrigation program review in Sri Lanka (part of an IBRD/FAO cooperative program: MPEA, 1968) is overwhelmingly oriented toward capital works and their planning and execution, and while recommending that there should be many more extension staff and stating the need for coordination at the field level, does not go into any detail about the procedures for achieving this. This was despite the terms of reference which included instructions to review and recommend institutional, organizational, manage-

Previously published as "Men and Water: The Organization and Operation of Irrigation," in *Green Revolution?: Technology and Change in Rice-Growing Areas of Tamil Nadu and Sri Lanka*, ed. B. H. Farmer (Boulder, Colo.: Westview Press, 1977), pp. 340-63. Reprinted by permission of Westview Press and Macmillan, London and Blasingstoke.

rial, and technical measures to ensure successful execution *and operation* of existing and future projects (my italics). Nor were the operational and organizational aspects of water management and their economic and social implications a concern of an international seminar on economic and social aspects of agricultural development in irrigated areas, held in Berlin in 1967 (German Foundation for Developing Countries, 1967). Finally, a recent publication of the National Commission on Agriculture in India dealing with modernizing irrigation systems and integrated development of commanded areas shows much the same blind spot: it embodies a top-down view of irrigation and omits operational detail (Government of India, 1973).

There are several reasons for this neglect (see also Chambers, 1975a, pp. 2–6): first, the common preoccupation with capital investment, construction, and settlement processes at the cost of the vital operating processes which follow; second, cramped vision from within narrow disciplinary boundaries, including mutual ignorance between social scientists and technologists and a reluctance to explore a no-man's-land between disciplines; third, the intensity of research required to examine what happens at the lower levels of administration, and difficulties in generalizing from one or a few cases, which are all that one researcher may hope to study; fourth, the maddening nature of water itself, with its tendency to flow, seep, evaporate, condense, and transpire, and the problems it presents in measurement—problems which tie down natural and physical scientists to research-intensive tasks, denying them time, even if they had inclination, to branch out and examine wider aspects such as the people who manage the water and how they behave.

These tendencies have left several gaps in comparative knowledge. Where water is administered to communities, there is a gap geographically between the last point at which it is officially controlled or measured and the point at which it enters a farmer's field. Organizationally there is a gap between what happens at the level of senior officials and what happens in the community which receives the water. Politically there is ignorance of the processes of decision making and allocation which influence the timing and quantity of water which farmers receive. In terms of political economy there has been little analysis of who gets what, how, when, and why, and with what costs and benefits. In terms of human management there is a widespread failure to perceive the problems and opportunities of managing those who manage the water, the men in organizations and communities.

This chapter uses the comparison of irrigation systems in the study areas in India and Sri Lanka as a basis for some preliminary steps among the minefields of interdisciplinary no-man's-land which these gaps represent. Much of the evidence is used with misgiving, being based on one-off interviews on day visits to villages and cultivation committee areas. For Sri Lanka, additional sources have been visits to and studies of the records of two major irrigation systems—Gal Oya and Uda Walawe. For India and elsewhere,

some secondary sources have also been drawn upon. The purpose is to open up some comparative, analytical, and practical aspects of the organization, operation, and political economy of irrigation.

A basic point is that water is usually a scarce resource for which men and groups of men compete and the benefits from which should be optimized in relation to other scarce resources. In the dry zone of Sri Lanka there is much evidence that water is more limiting than land (Chambers, 1975a, pp. 19ff.), although scarcities of draught power and labour are also constraining (Harriss, 1976) and may at some times and places be more limiting than water. In parts of North Arcot the scarcity of water is even clearer and more acute. Surface irrigation water from tanks is often inadequate for a second crop and the groundwater level is undergoing a serious secular decline as numbers of wells grow, more pump sets are installed, and groundwater extractions increase (Madduma Bandara, 1976). As population presses more and more on the resources available for food production in these and other environments, so understanding the relations between people and water for irrigation becomes a more and more vital priority.

Typologies of Irrigation

A first step is to try to identify useful categories. The descriptive terms used by engineers and agriculturalists dominate discussion of irrigation systems. This is partly because they themselves have such key roles in irrigation, partly because their categories refer to physically observable phenomena such as structures, field layouts, and methods of water application. These categories may not be the most useful ones for an analysis of the organization and operation of irrigation. But classifying the irrigation systems encountered in Sri Lanka and India in terms of their more obvious physical characteristics does provide a starting point.

In the study area in Sri Lanka almost all irrigation is by surface gravity flow, most from storage tanks. Tank water is received from various combinations of catchment run-off and river diversion. Scarcely any wells are used for irrigation. The commonly used classification of gravity-flow irrigation into "major" and "minor" corresponds with differences in scale and organization, not with differences in physical type of source, conveyance, or storage of water. The management of water under major irrigation is the responsibility of the Territorial Civil Engineering Organization (TCEO), which distributes it down to the field channel level. Water management on minor irrigation is the responsibility of village communities, which organize their own distribution systems. Under a major irrigation project there are usually several cultivation committees, whereas under minor irrigation there is usually only one.

From the more obvious characteristics of scale and type of water source and storage, the cultivation committees in our sample can be classified as in

Table 2.1. In all cases, distribution from the tank or from the main canal is by gravity through channels of diminishing size to farmers' fields. There is only one well and pump known under any of these systems (under Tissawewa tank) and that is not in one of the survey cultivation committee areas.

In the study area in India there is a greater variety and mixture of irrigation systems. The most common form of gravity irrigation consists of canals from anicuts from rivers which are dry for most of the year, and which supply chains of village tanks in series. In our sample, large tanks are represented only by Dusi, which is one of 18 villages served by the large Dusi-Mamandur tank. In addition, in all villages there are wells used for lift irrigation. Three forms of lift are used—etram (human power), kavalai (ox power), and pump sets (oil or, much more commonly, electric power). These wells are usually found both on the dry land (land which is not under command for tank or channel irrigation) and on the wet land (under command for tank or channel irrigation). The villages in the sample can be classified as in Table 2.2.

The categories in the table follow the necessary but well-worn discipline-bound criteria of engineers and hydrologists. They are much concerned with the acquisition, transport, and storage of water and less with its distribution. An engineer talks and thinks in terms of diversion channel, tank, dam, gravity, well, pump, major and minor irrigation, with type of structure and scale of operation as his main criteria. A hydrologist thinks and talks in terms of water cycles and sources of water—shallow or deep well, spring, surface run-off storage, and river diversion irrigation, for example. But other disci-

Table 2.1.

Water source and storage categories

Cultivation committee	Minor/ Major	Water source	Storage system
Kachchigala	Minor	Small catchment run-off	Small tanks
Metigatwala	Minor	Small catchment run-off (now supplemented by major irrigation)	Small tanks
Kataragama	Minor	Small catchment run-off	Small tank
Tenagama	Minor	Small catchment run-off and spills of higher tanks with small area sometimes supplemented by major irrigation	Small tanks in series, close together
Wellawaya	Minor	Anicut and channel from permanent stream	Nil
Hanganwagura, Jansagama, Rotawala	Major (WRB)	Anicut and long channel from Walawe river with perennial flow	Nil
Jayawickremayaya	Major (KOLB)	Anicut and channel to tank from Kirindi river (water not always available)	Tank (Debarawewa)
Kachcherigama	Major (KOLB)	Anicut and channel to tank from Kirindi river (water not always available)	Tank (Tissawewa)
Udasgama	Major (KOLB)	Anicut and channel to tank from Kirindi river (water not always available)	Tank (Tissawewa)
Companniwatta	Major (KORB)	Anicut and channel to tank from Kirindi river (water not always available)	Tank (Wirawila)

WRB = Walawe right bank; KOLB = Kirindi Oya left bank; KORB = Kirindi Oya right bank.

Table 2.2.

Village classification

Village	Non-well water source	Tank storage	Wells in wet land	Wells in dry land
Kalpattu	Nil	Nil	No wet land	Yes
Vegamangalam	Excavated springs near river, permanent flow	Nil	Nil	Yes
Dusi	Channels leading from large seasonal rivers	Large tank	Negligible	Few
Meppathurai, Vinayagapuram	Channel leading from seasonal large river direct to village tank	Village tank	Yes	Yes
Amudur, Duli, Randam, Sirungathur, Vayalur, Veerasambanur, Vengodu	Combinations of natural drainage lines and channels from seasonal rivers leading through chains of tanks to village tank	Village tank	Yes	Yes

Note: Some villages have additional small tanks which are fed by catchment run-off. All tanks receive some water from their catchments in addition to amounts received from the source named.

plines would classify irrigation systems quite differently: for an agriculturalist the field application of water is central and includes flood, border strip, check basin, furrow, underground, and sprinkler irrigation. In the social sciences the only large-scale attempt at comparative analysis of the organization and operation of irrigation has apparently been Wittfogel's eccentric polemic on oriental despotism (1957), although a recent start in classification has been made by Thornton (1976). After considering the physical acquisition and transport of water, Thornton points out that it is with distribution that "the largest number of organizational alternatives occur." Distribution is also a potential focus for classification since it corresponds with much of the unexplored no-man's-land in irrigation.

Categories depend both on the subject matter and on the orientation of the observer. Classifications of irrigation organization can themselves be classified as top down, bottom up, or middle outward, depending on the focus of concern and the stance of the typologist. Thornton's types derive from a top-down view, using formal organization and the distribution of responsibilities within the organization to separate out categories, with a major division into private and public organizations. A bottom-up view of irrigation, starting with the farmer and his preoccupations, might differentiate between irrigation systems according to the cost, adequacy, convenience, and reliability of the supply of irrigation water to the farm. A middle-outward view of irrigation organization would start geographically and organizationally in the middle of the distribution system. It might differentiate systems according to the decisions, communication, and allocations which affect distribution, looking both upward toward the source from which the water derives and downward to the farmer. All three views—top down, bottom up, and middle outward—deserve to be developed. Here we will start in the relatively unex-

plored middle ground and move outward from there, paying particular attention to the organization and operation of communities and bureaucracies in the distribution of water.

A central and universal issue in the distribution of irrigation water is who gets what, when, and where. This is the very stuff of politics and it is surprising that political scientists, political anthropologists, and those who study political economy have not devoted more attention to it. Where water is scarce and often constraining and when individual farmers and communities of farmers compete for it, the focus is on the processes of allocation and acquisition which determine the access of users to water. These processes can be classified as:

Direct appropriation	The user acquires water directly from a natural source such as a private dam or well.
Acquisition through contract	The user acquires water through agreement with a supplier in exchange for goods or services.
Community allocation	A communal source of water is allocated among a community of users.
Bureaucratic allocation	Water is allocated by bureaucratic organization direct to individual users.
Bureaucratic-communal allocation	Water is allocated by a bureaucratic organization to one or more communities of users, each of which manages distribution to its members.

These types are represented in the examples available as in Table 2.3. The categories adopted must be treated warily. They are designed for convenience

Table 2.3.

Water allocation

Type of allocation/ acquisition	Sri Lanka	India
Direct	Negligible	Very common (individual wells)
Contract	Negligible (except where tenancy carries water rights)	Negligible (except where tenancy carries water rights)
Community	All minor irrigation (Kataragama, Wellawaya, Tenagama, Metigatwala, Kachchigala)	Amudur, Duli, Meppathurai, Randam, Sirungathur, Vayalur, Veerasambanur, Vegamangalam, Vengodu, Vinayagapuram
Bureaucratic	Uda Walawe	Nil
Bureaucratic-communal	All major irrigation (Hanganwagura, Jansagama, Rotawala, Jayawickremayaya, Kachcherigama, Udasgama, Companniwatta)	Dusi

without necessarily implying that they have great explanatory power. As with many other distinctions in the social sciences, the edges blur and overlap in practice. Thus Dusi is immediately a bad fit in bureaucratic-communal irrigation, since the size of the paddy tracts under the large Dusi-Mamandur tank would lead anyone familiar with irrigation in Sri Lanka to look for a bureaucracy which distributes the water; but in the strict sense of bureaucracy—an organization with its own norms, roles, terms of service, and so on—there is none. The PWD only controls issues from the tank sluices, leaving the rest to the traditional officers of the villages. Again, Amudur, though having a community system of allocation and acquisition, has something verging on its own "bureaucracy" in the form of three Harijan thoddis who distribute the water to individual farmers. These two examples are cited not to undermine the classification, but to discourage any tendency to think that words refer to classes of entities which are more consistent and distinct than they really are.

Analysis will concentrate on those types of which there are numerous examples: direct acquisition, almost entirely through wells in India; community allocation, widely represented in both Sri Lanka and India; and bureaucratic-communal allocation, mainly in Sri Lanka. The focus will be further narrowed by concentrating on the levels at which decisions and actions affecting allocation and acquisition are taken; for these three irrigation types they are as shown in Table 2.4.

The main attention will be at the community and system levels. "Community" here refers to users with an interest in a common source of supply, the water from which is distributed among themselves. This usually refers to what in Sri Lanka is called minor irrigation, to what in India is village tank irrigation, and in both countries to groups of users on larger irrigation projects who depend upon the same feeder. "Systems" refers to whatever organization or arrangement exists above the community level for the management and allocation of water.

The discussion which follows is in two sections: the first deals with the organization and operation of community irrigation, examining allocation and appropriation of water, equity and productivity, enforcement and arbitration, and action by irrigation communities; the second deals with the organization and operation of bureaucratic-communal irrigation.

Table 2.4.

Levels of decisions actions

	Farmer level (within fields)	Community level (within community area)	System level (within irrigation system area)
Direct	Yes	No	No
Community	Yes	Yes	No
Bureaucratic-communal	Yes	Yes	Yes

Community Organization and Operation

The Allocation and Appropriation of Water

The allocation and appropriation of water can be described in terms of two stages: decisions about areas to be irrigated and about timing; and actual allocations and appropriations.

In the first stage a decision may have to be taken as to which areas under command to irrigate. Leach has described for Pul Eliya in Ceylon the nice decision which has to be taken with a village tank:

> The issue is a subtle problem of economic choice since, if the water resources of the irrigation system are overextended, the outcome may be total crop failure. The village meeting makes its collective decision on the basis of the level of water in the tank and a gambling estimate of rain in the weeks to come. [Leach, 1961, p. 53; Chapter 5 below, pp. 103–4]

This type of decision is not limited to village tanks. Wellawaya depends on diversion from a small perennial stream which is not always sufficient for all of its six blocks of asweddumized land; similar decisions have to be taken about which and how many of the blocks to cultivate in Yala. The only Indian village in the sample known to have a similar system is Duli, where, when water is short, a decision is taken to allow the same fixed acreage to each holder of wet land and to supply water only for that. Under the other Indian villages with tanks there appears to be no formal decision about the acreage to be cultivated: the decision is left to individuals, who must rely on their own judgment of the water likely to be available and their chances of obtaining enough of it, through whatever system of allocation and appropriation operates and subject to the physical layout of the irrigation system and of their fields. Where, as in Vegamangalam, there is a perennial supply of water adequate for more or less continuous cropping, the question of which land to irrigate or not to irrigate does not arise in the same form but depends on the timing and phasing of cultivation operations.

The second stage of decision is the allocation and appropriation of water within an irrigation community, affecting those areas which it has been decided to irrigate. There are at least four forms this can take:

1. A physical division of waterflows between channels. The *karahankota* described by Leach for Pul Eliya (1961, pp. 160–66 [Chapter 5 below, pp. 119–22]) is an example. Water was divided by a wooden weir into which flat-bottomed grooves of various widths had been cut, the water allocations being the amounts of water which flowed through different grooves into different channels. The physical system (though not the proportional allocations) had fallen into disuse in Pul Eliya even in 1954 and no case of any similar system was found in our survey either in Sri Lanka or in India.
2. Rotational rationing on a roster basis. This is widespread throughout

the world. The warabandi system in Haryana (Vander Velde, 1971, p. 132) and the waqt (sunrise to sunset or sunset to sunrise) system in Iraq (Fernea, 1970, pp. 124–25) are examples. In our survey we found that time had been estimated in various ways in the past including judging by the sun during the day and by the stars at night, measuring the lengthening shadow of a stick either in finger breadths or paces (Amudur), and taking the time a leaking pot took to empty (the murai palla system in Vengodu). These methods have, however, fallen into disuse and have been replaced by the wristwatch, sometimes in Sri Lanka combined with paper chits (tundu) as in Wellawaya and Companniwatta (where four-hour spells have been used in periods of scarcity). In several Indian villages in the sample there was a karai system in which a sequence of turns was taken by family groups, the duration of the turns being a matter of tradition. But given the dispersal of family lands and the complication of pump sets, what happens in practice must be an open question. A principle often stated, however, was that the duration of water was related to the acreage owned or to the acreage actually cultivated in the season in question.

3. Allocation by restricted acreage. The rationing system at Duli is based on the principle that each cultivator should restrict his acreage to a fixed amount and then, in rotation, be supplied with the water needed. This has some similarities with the bethma system in some purana villages in Sri Lanka (Farmer, 1957; Leach, 1961) in which, in a season when acreage had to be restricted, all holders of wet land were able to cultivate a portion of the irrigated field.

4. "Anarchy." Water may be not so much allocated as appropriated, as described by John Harriss for part of Kirindi Oya right bank: "I have found ... the suggestion of a kind of anarchy in which in time of scarcity water supplies depend upon the strength of a man's right arm" (1976, p. 16). The apparent disintegration of traditional allocation systems under Indian village tanks may also sometimes verge on this situation.

Equity and Productivity

These two sets of actions—deciding the location and timing of irrigation, and then the allocation and appropriation of water to those lands which are being cultivated—raise acute questions of equity. Rural inequity is often associated with differing sizes of landholdings. But this misleads when a man with a secure water supply is able to crop his land three times a year while a man who has to rely on only one irrigation takes but one crop. The physical position of fields relative to channels is critical. Those near the top of channels have an immense physical advantage of access which it can be very difficult for those farther down to control. In the absence of countervailing custom, social sanction, or physical force, the privileged top-enders satisfy their own

needs first before allowing water to flow on down a channel to their less fortunate neighbors below. The tail-enders often receive less water less reliably and in a less timely fashion than those near the top. There is a striking variation in the extent to which the communities studied in India and Sri Lanka moderate these inequities and in the methods they use.

In India the most common systems for distribution under tanks favor those at the top end. In Meppathurai, Randam, Sirungathur, Vayalur, and Veerasambanur, top-enders are said to take water first. Moreover, the karai system, and any other system of time rationing, is liable to deliver less water to tail-enders because of seepage and evaporation losses en route (see Vander Velde, 1971, *passim*). However, informants from Vinayagapuram, Amudur, and Vengodu all claimed to have systems which made special provision for tail-enders in time of water scarcity: in Vinayagapuram, the first issue was said to be from the top downward with the second issue in reverse from the tail end upward back toward the top; in Amudur since about 1955 it was said that water had been issued to tail-enders first (this was part of a major reform in which the supervision of water allocation was also changed); and in Vengodu, where tail-enders had been suffering, a partially effective convention was said to discourage those with pump sets in the wet land from using tank water so that it could be supplied to those less fortunate cultivators who did not have pump sets. It is, however, Duli's system, allowing adequate water to equal plots of land, which scores highest for equality. In Sri Lanka the systems also varied but information on them is incomplete. On major irrigation, however, the practices appeared to follow the principle of "the devil take the hindmost."

Questions of equity are linked with questions of productivity. With food production a major objective and water a critically scarce resource, measures which might be more equitable have to be weighed also in terms of productivity. The main issue is that the conveyance of water involves losses through percolation and evaporation. Duli scores highly for equity but the water losses in distributing water as in Navarai 1972 to small plots of 0.3 acres each scattered over the ayacut must have been substantial. Had it been possible to adopt an equivalent of the bethma system, in which all cultivators participated but in which the water was applied to one block of land near the tank, then the productivity of water and the total output of the land should have been higher. Similarly the supply of water to tail-enders first is wasteful, not only in conveyance losses but also in the loss of opportunity to reuse drainage water and to raise the water table; for when top-enders in an ayacut take water first, seepage in their fields may raise the water table lower down and thereby reduce subsequent water duties there, and surface run-off into drains may be reused by cultivators nearer the tail end, as at Kataragama and under Tissawewa in Sri Lanka.

The questions are complex and interlinked with the patterns of wealth and

power in irrigation communities. Any government may hesitate to intervene in such a difficult policy area; but several of the Indian villages had themselves within living memory changed their water allocation systems, in one case at least (Amudur) in the direction of greater equity in distribution. The systems used are by no means a sacred part of the social fabric, to be tampered with only at the risk of severe disruption. The evidence suggests that water distribution under tanks was usually both inequitable and inefficient in terms of productivity. A particular example is the tendency for those with water available from wells and pump sets none the less to take tank water (since they do not have to pay for it), denying it to their less fortunate neighbors who may not have wells. The result may often be that a village cultivates a much smaller area than it could if the pump-set owners were to use only well water. Could those with pump sets be persuaded or forced to forgo tank water? The suggestion was greeted with laughter in Randam and Vayalur, but informants in Vengodu suggested that some such idea was at large there and might even be partially implemented. If, with the introduction of pump sets in wet land and the progressive fragmentation and dispersal of family lands, the distribution systems under tanks in North Arcot are looser and less effective than in the past, this may be a time when an official initiative to increase both equity and productivity is feasible. Differential taxation to provide an incentive to pump-set owners in the wet land to abstain from using tank water might be considered.

Enforcement and Arbitration

An intriguing set of questions arises over infringements and disputes and their adjudication. There is a sharp contrast between Sri Lanka and India. John Harriss has described (1976) the work of the *vel vidanes* who were appointed by government under the colonial regime in Sri Lanka, armed with authoritarian powers, and remunerated with a share of the crop; and the subsequent system of enforcement through the elected administrative secretaries (Govimandala Sewaka) of the cultivation committees, who received 40 percent of an acreage tax. It seems to be widely accepted that the vel vidane system could be quick-acting and technically efficient, whereas the cultivation committee system has always been slow-acting and permissive. Cultivators canvassed in our survey gave responses which can be interpreted as preference for a system, whether vel vidane or other, which was authoritative, quick, and effective (Chambers, 1976b, text and Appendix A). It would be easy, if no other system were known, to conclude from this that a more authoritative and more efficient system is needed at the irrigation community level; that a committee cannot perform this function; and that a man whose reward is unrelated to the value of the crop is unlikely to perform it well.

The contrast with the Indian villages is then striking. Under the South

Indian tanks there is no equivalent of the vel vidane. There is no tradition of a government servant being concerned with allocations within the paddy tract under small tanks. The system is radically different. Whereas the vel vidane was usually an influential and prosperous local person, those responsible for the execution of water control in the South Indian villages are Harijans, the thoddis or neer thoddis. Their responsibilities vary considerably, as does their remuneration. In some villages they are responsible only for closing and opening the sluice. In Amudur, however, they have extensive responsibilities in executing the allocations in the paddy tract. One of the three Amudur thoddis said (1974) that he would never allow anyone else to move water and if they did there would be an ur panchayat meeting and the miscreant would be fined; but this had never happened. Evidently, if our informants were correct, rights and allocations in Amudur are clearly understood and the thoddis have clear guidelines to follow. One Amudur farmer went so far as to say that under the system practiced before 1955 there were many disputes, but now he did not even bother to go to his fields when water was due as he had complete trust in the fair operation of the system by the thoddis.

The extent to which an arbitration role is demanded must depend on the extent to which there are infringements or, in the absence of clear rules, the extent to which there are acts which cause serious resentment. No doubt cultural differences and different developmental experiences profoundly influence attitudes toward different forms of arbitration. But appeals to outside authorities are common. On the basis of a comparison of fifteen irrigation systems in the Philippines, Ongkingco has written, "It is striking to note the satisfaction of farmers when somebody in authority, like a policeman or a major, attends to water distribution problems. Under these circumstances, farmers even seem to be satisfied with reduced water supplies" (Ongkingco, 1973, p. 242). In Sri Lanka, one administrator has lamented the volume of cases and appeals presented to him over water matters, deflecting him from the main task of stimulating agricultural production (Weerakoon, 1973, p. 7). Performing these arbitration functions, whether the arbitrator is a government servant or a local person, is not easy. Administrative secretaries interviewed in Sri Lanka were generally unenthusiastic about their work, several of them complaining about the arduous duties involved. In the Philippines again, Ongkingco found one hereditary water master (whose duties were roughly similar to those of an administrative secretary) who wanted to relinquish his position because he got no benefit from it, but felt he could not do so because of community tradition (Ongkingco, 1973, p. 240).

One objective of government policy may be to improve equality and productivity while avoiding involvement in administrative costs. Once government intervenes, there is a danger of an endless series of cases and appeals, and of a need to provide more staff to deal with them. There is also a danger of inducing attitudes of dependence among communities. To secure a "fair"

distribution of water within irrigation communities may often be difficult (and in any case there are problems with the connotations and interpretations of "fair"). But cultivators do appear generally to agree that they value quick action. And even where governments cannot institute "fairer" distribution of water, there may be opportunities for them to enable crucial decisions and judgments to be made more promptly.

Action by Irrigation Communities

Governments benefit if they can rely on action by irrigation communities for the operation and maintenance of irrigation works. The survey villages are of interest because they present four cases in India where considerable communal labor is called for to maintain an irrigation system, one of which has collapsed; and one case in Sri Lanka of partial collapse.

The four cases in India all involve work required to acquire and transport a communal water supply. They are Dusi, Vegamangalam, Meppathurai, and Vinayagapuram.

The Dusi case involved collaboration between the eighteen villages served by the Dusi-Mamandur tank. On 16 August 1971 the Dusi-Mamandur irrigation board, consisting of one representative of each of the villages, a secretary, and a president, met to decide how to secure the flow in the channel from the anicut to the tank. This, they maintained, was the responsibility of the PWD, but as the PWD could not be relied on to act swifty enough, the villages themselves had to take action. They decided that each village should send labor at the rate of one man to every ten acres irrigated, in order to divert the Palar River into the channel. The work was apparently successful.

The Vegamangalam case is a continuing and customary activity. When the long channel bringing the spring water to the pangu lands of the village requires a cleaning out, every family with a share provides labor at the rate of one man per anna of land (1.6 acres of wet plus 0.74 acres of dry). The system apparently works well.

The Meppathurai case is an example of a practice abandoned: of what it was there were several differing accounts. What was agreed is that the run-off flow into the Meppathurai tank had for many years been supplemented by a channel from the Cheyyar River. When the river flooded, villagers dug in the river and in the channel to divert water into the channel and along it to the tank. Much work was involved in removing silt from the channel. In about 1967 there was a heavy flood and the channel seriously silted up. According to some, the task of clearing was too great for the village and appeals for government assistance failed. Others state that there were political differences between the larger, older farmers (who were Congress supporters and stood to benefit more from clearing) and the smaller, younger farmers (who were DMK supporters and stood to benefit less). Yet another contributory factor

may have been a high degree of absentee ownership of wet land. It is also possible that the farmers were not unduly concerned because they could anyway rely on their pump sets in the wet land. But whatever the cause, Meppathurai failed either to obtain government assistance or to carry out the clearing itself. In 1974, some six years later, the situation was even less remediable; the two miles of channel were heavily overgrown with bush and the poorer people who used it as a source of firewood for sale were opposed to any clearing.

The Vinayagapuram case is an interesting contrast. The main water supply for the tank comes from a five-mile channel taking off from the Cheyyar River. This requires extensive and heavy work to clear off sand during the period from the beginning of January until the end of April. All those cultivators who benefit from the channel have an obligation to clear three feet per day for every acre of wet land they hold. The work is closely administered and arduous, but the second (Navarai) crop depends on it. There is a long history of conflict with Konaiyur, a village which lies astride the channel above Vinayagapuram but which has no rights to the water. Twenty years ago, when the channel silted very badly and Vinayagapuram was appealing for government help to clear it, Konaiyur people said they would clear it and take it over. However, Vinayagapuram obtained government assistance and managed to continue maintenance. More recently, theft of water by people from Konaiyur has led to violence and court cases. When the channel is running, Vinayagapuram posts night guards where it runs through Konaiyur. Since the main crisis twenty years ago the system of communal labor appears to have been continuously effective.

The final case, from Sri Lanka, raises the issue of the division of maintenance responsibilities between communities and bureaucracy. In one instance, a long canal was heavily silted and overgrown. Partly because of this, water only reached the tail end four to six weeks after it began to flow at the top. It was in the interests of the tail-enders but not of the top-enders that the canal should be cleaned and maintained. The maintenance responsibility lay with the Territorial Civil Engineering Organization, which was unable to carry it out. The TCEO suggested that the communities themselves should clean the canal. The tail-enders, in whose interest it was that the canal should be cleaned, might have done the work, but by then the top-enders already wanted water. The result was no maintenance and continuing inefficiency and inequity in water distribution.

These examples support common-sense conclusions about communal labor. First, communal labor is most likely to be effective where the community will benefit directly and where labor obligations are proportional to expected benefits. Thus Dusi and the other seventeen villages could mobilize labor to divert the river into the tank, and Vegamangalam and Vinayagapuram maintained their channels. In all these cases the labor obligation was related to

irrigated acreage. Conversely, where there is no direct link between the work done and the benefits gained, communal maintenance will be much more difficult. One of the reasons given for the abandonment of the Meppathurai channel was that the young men and small farmers felt that they were being required to do more than their share in relation to the benefits they might expect. Even more so, it is unrealistic to expect maintenance to be undertaken by people who will not benefit at all, as with clearing of silt at the top of channels by top-enders, which only helps those farther down.

A second conclusion concerns the role of government. Intervention to help a community may be critical in sustaining a system of communal maintenance when it is under exceptional stress. Vinayagapuram's system survived after a successful appeal for government help; Meppathurai's collapsed after a similar appeal failed. The judgments involved are nice since too much help too easily given generates attitudes of dependence which in turn may lead to collapse. One error to avoid is uncertainty about the physical boundaries of responsibility for maintenance. Such uncertainty arose in Sri Lanka following an instruction to the TCEO (which was not well received by staff at the local level) that they should extend their maintenance work farther down some channels. The outcome of such a situation is liable to be that neither government nor the community maintains the works. In general, government should unambiguously avoid doing what communities can do for themselves in their own interests, but should intervene when exceptional problems are beyond a community's power to overcome.

A third conclusion is that those who design irrigation systems in countries where labor is abundant and government poor should consider designs which encourage community action. These require that the maintenance work shall be within the capacity of the numbers of cultivators anticipated, and that they shall benefit from the work being done. The recurrent costs to government of the irrigation system should then be less than if government itself were obliged to provide maintenance. Higher capital costs, for example with more separate channels to communities which would then maintain them, might be justified by reducing the recurrent costs of maintenance by government.

Bureaucratic-Communal Organization and Operation

Perhaps the most interesting, important, and difficult questions concern the organization and operation of bureaucratic-communal irrigation, in which water is controlled first by a bureaucracy and then by a community or communities. The issues which arise within irrigation communities also arise now within the bureaucracy, between the bureaucracy and the communities, and between communities. The problems of water allocations between competitors, the questions of productivity and equity, and the difficulties over enforcement and adjudication which all occur within communities are now

replicated but on a bigger, more visible, and sometimes more dangerous scale on the larger irrigation system.

Although the variations are legion, a recurrent concern and source of intercommunity conflict on bureaucratic-communal irrigation arises over the allocation and appropriation of water. With community irrigation, without a bureaucracy, we have already seen how the poaching of Vinayagapuram's water by farmers from Konaiyur, higher up the channel, led to violence and litigation, with the difference that there is a mediating bureaucracy. Common practices include constructing illegal outlets, breaking padlocks, drawing off water at night, and bribing, threatening, or otherwise in some way inducing officials to issue more water. Typically those at the top end get their water first and get most of it, while those at the tail end suffer. Many examples could be given. On Kirindi Oya right bank canal in Sri Lanka, there are several extra pipes off the main canal which were not part of the original irrigation design (personal communication, John Harriss) extracting water higher up, often to the detriment of those lower down. In North India the tension between villages may erupt into serious threats to law and order. Vander Velde reports an intervillage dispute in which ten cuts were made in an embankment in less than twenty-four hours and major violence between villages threatened (1971, p. 154). Both in the allocation of water and in the execution of the allocations the competition between communities is an inescapable problem.

Productivity and equity are involved here, as they are in intracommunity distribution. Other things being equal, water is less productive after conveyance losses to the tail end of a channel than if it can be applied at the top end. Moreover, when a canal is long, conveyance losses are high, and delays in the arrival of water at the tail end run into weeks or even months, as they do with the seventeen miles of the Walawe right bank in Sri Lanka, then planting at the tail end becomes untimely, either forcing cultivators to grow lower-yielding, shorter-duration varieties, or involving them in risks of inadequate water at critical periods in the growth of the crop, or condemning the crop to climatically suboptimal conditions, or some combination of these. Excessive extractions higher up commonly contribute to these delays and inadequacies of supply to the tail end. On much major irrigation in Sri Lanka it is notorious that top-end farmers flood their fields more than is necessary for the growth of paddy and substitute water for labor in weeding, with little or no regard for their neighbors waiting dry farther down the channel. Their behavior is rational, given their interests; but it is also antisocial, both in denying their less fortunate neighbors timely and adequate water and in denying the country the additional paddy which their neighbors might be producing. The same is true with water issues on the two largest schemes in Sri Lanka—Gal Oya and Uda Walawe—where the acreage cultivated is much less than it might be because of permissive and excessive water issues. In the one Indian example of

bureaucratic-communal irrigation (Dusi-Mamandur) the problem may be less acute, but even there tail-enders complained that they could grow fewer crops in the year than top-enders.

The challenge here is to be inventive in devising institutions and relationships which will moderate intercommunity strife and be both equitable and productive in the allocation and application of irrigation water. There are four clusters of functions to be performed:

1. Strategic decisions about water use, including timing, amounts, allocations to communities, which lands to be irrigated, what crops to grow, and the maintenance of channels.
2. The execution of those decisions.
3. Allocation of water and arbitration *within* communities.
4. Policing, and prosecution of infringements.

The question is how officials on the one hand and communities of users or their representatives on the other should be combined or separated in order best to perform these functions. A problem here is the word "best." The criteria for evaluating solutions already include the productivity of water and the equity of its distribution. To this some, democrats, would add maximizing participation by the users, while others, technocrats, would add its antithesis, maximizing the decision making and control by tehnical staff.

In deciding the balance to strike between the democratic and technocratic views it is chastening to reflect on the side differences which can be observed. At one extreme is the system operated under the Dusi-Mamandur tank in India, with its ayacut supporting eighteen villages. Intercommunity water allocation decisions are made by the president of the irrigation board elected by the villages. Villages send their traditional functionaries to him with requests for water which he then forwards, after whatever amendment he judges necessary, to the section officer of the PWD, who instructs one of his staff to open or close the sluice from the dam accordingly. In Sri Lanka, on this size of irrigation system, the distribution from the channels below the tank would be the responsibility of government staff, but according to the evidence given, all water movement below the Dusi-Mamandur tank is the responsibility of an irrigation board of village representatives. Among the examples available, this is an extreme version of user participation in strategic decisions and their execution. At the other extreme are projects where the bureaucracy controls water issues right down to the level of the farmer (as on Uda Walawe in Sri Lanka) or even to his individual field (as on the Mwea irrigation settlement in Kenya [Chambers and Moris, 1973]).

Both extremes have disadvantages. The Dusi-Mamandur system is probably inefficient in water use: certainly there is an irrigation engineering opinion that water use would be much less wasteful if the bureaucracy controlled water issues from the main canals to the irrigation communities; certainly too,

the tail-enders only manage one or at best two crops a year while those at the top end regularly have two or even three. With tighter management the distribution of water might be both more productive and more equitable. On the other hand, the bureaucratic extreme, as on the Mwea irrgation settlement, is expensive in government staff and in the associated loss of community self-management and communal labor for maintenance. Government is liable to be doing for communities what they could and would otherwise do for themselves. Some middle course between these two extremes may combine greater productivity and equity without forgoing communal labor and without the need to maintain a large bureaucracy.

Taking this point of view, we can examine the four clusters of functions and see how they might be allocated.

First, there is a good case for strategic decisions being taken jointly by representatives of users and by government officials. Where representatives of users take decisions alone, they are likely to lack some of the technical knowledge needed, as probably on Dusi-Mamandur. Where administrators or technocrats take decisions on their own they are liable to ignore some needs of users, leading to later difficulties. Moreover, as the assistant government agent Hambantota wrote in 1922, "The proprietors are more likely to adhere to dates which they have agreed to than to regulations imposed from without" (letter to Government Agent, Southern Province, 8 November 1922; Hambantota Kachcheri file E85). Better decisions are likely where they result from discussion which benefits from an engineer's knowledge of water availability, an agriculturalist's appreciation of the cropping position, farmers' knowledge of their resources and problems, and a presiding administrator's appreciation of all of these. This is very much the system practiced in water meetings in Sri Lanka, presided over by government agents. In that form it has both strength and weakness in the openness of the meeting to all farmers affected and who may or may not fairly represent all the interests involved. Given the large attendances, it is not surprising that they decide on dates for operations (such as opening the sluices from a tank, starting cultivation, and completing water issues) but do not decide the detail of rotational issues. Were there a more representative but smaller body, elected by "irrigation constituencies" which would ensure that tail-enders were included, then it might be possible for such meetings or a succession of them to decide in more detail what system of water issues to communities, with what volumes of water, should be adopted.

Second, with the execution of these decisions the question is how far the bureaucracy should extend down the irrigation system. On Dusi-Mamandur it is restricted to the sluice itself. On major irrigation in the dry zone of Sri Lanka it extends down the main channels to the points at which water is issued into field channels to communities. Communities are unlikely to agree among themselves that those higher up will take less in order that those lower down may benefit. More usually, an independent and impartial organization is

needed and this is mostly some form of bureaucracy. The need of such bureaucracy is underlined by the experience of the elected Thannimurrippu Paripalana Sabai, reported by Ellman and Ratnaweera, who state that while strategic decisions were satisfactorily taken, the problem was implementation and enforcement in which the elected body was not interested (Ellman and Ratnaweera, 1973, pp. 10, 15). There were difficulties over the blurred division of responsibilities between the elected body and the government officers and "depersonalizing the process of rule enforcement" was needed (ibid., pp. 8–9, 27). A crucial link is, it seems, between the strategic decisions and those who implement them. A degree of impartial independence is required, with willingness and ability to carry out instructions earlier arrived at without bowing to particularistic local pressures. For this, a bureaucracy loyal to the decisions, but with its discipline partly deriving from a larger national or regional department, seems the most promising solution.

Third, allocation and arbitration within communities can usually be left to those communities, with perhaps some provision for appeal and for intervention by the bureaucracy in emergency. If water has to be rationed on a rotational basis, the difficulties of allocation within the community irrigation tract may be lessened if, as suggested by Levine et al. (1973, p. 11), the intermittent issues of water are large.

Fourth, there is a persistent need for policing and the prosecution of infringements above the community level. These are sometimes carried out by communities themselves. Vinayapuram's night guards on its canal where it passes through Konaiyur, and the observation of the Dusi-Mamandur president (interview, May 1974) that, if government were to be responsible for distribution below the tank, it would be continuously necessary to call in the police, are reminders of the power of community organization. But it is also noteworthy that under Dusi-Mamandur there was ten years of conflict between two villages, Pallavaram and Kanikillupai, over the height of a weir alleged to be diverting too much water to one village to the detriment of the other, a dispute which provoked intermittent damage and repair to the offending structure. Wherever water is scarce, communities resent extraction of water from higher up on their own supplies, whether apparently legal, as with a rubber company upstream from Wellawaya and with two pumps in the river above Vinayagapuram, or evidently illegal, as with the surreptitious raising of diversion weirs, the use of pumps at night to lift water from channels, the digging or breaching of canal banks, and the like. For these, if not a police force, then something like one is needed.

Police are anyway quite often called in to intervene with both allocation and enforcement. During the crisis of water shortage on Kirindi Oya right bank in *yala* 1922, police helped with the allocation of water (letter, Divisional Engineer SD to the Director of Irrigation, 25 August 1922, Hambantota Kachcheri file E85). In the intervillage conflict in Haryana cited by

Vander Velde, "the resulting inter-village acrimony required the intervention of the police on a major scale to prevent serious violence" (Vander Velde, 1971, p. 154). In India the Irrigation Commission of 1972 drew attention to the need for efficient policing and prosecution and to "the success which has been achieved in Haryana through extensive patrolling and inspection of canals and channels by flying-squads of officers, adequately armed. These flying squads carry out surprise night inspections and whenever offenders are caught, heavy penalties are imposed on them. The essence of the system is surprise, and prompt and condign punishment. A similar system of inspection by flying-squads could be adopted with advantage elsewhere" (MIP, 1972, p. 300). A widespread complaint in Sri Lanka was precisely the lack of "prompt and condign punishment." Within communities, administrative secretaries rarely bothered to file cases which they knew would be subject to long delays; and at a bureaucratic level many cases filed by government servants were not heard for months, or even years.

A careful mix of relationships may be best: with user participation in strategic decisions and with management by communities of their own water supplies once allocated, but with a disciplined organization responsible for executing decisions, policing the system, and prosecuting delinquencies. It has to be made rational for the staff involved to deny resources to people who want them, in particular to issue less water to top-enders than they would like to receive. To achieve this the bureaucracy needs, first, high-level political support, and second, an internal style and supervision and incentive system which supports and rewards such unpopular actions (Chambers, 1975b and 1976).

Comparisons, Theory and Practice

These various comparisons help toward some theoretical and practical conclusions.

At the theoretical level, irrigation presents social scientists with tantalizing invitations, too rarely taken up, to speculate. Expressions like "irrigation society" and "hydraulic organization" hint that there may be strong causal links between irrigation systems and technology and social and economic relations. Irrigation organization has an appearance of inevitability which lends itself to deterministic interpretations. Wittfogel (1957) succumbed to the temptations presented by the apparent imperatives of large-scale irrigation, requiring, as he saw it, totalitarian organization in order to muster the labor forces necessary for the maintenance of hugh flood-control works and irrigation systems. This is not the place to discuss the validity of his thesis. The importance of Wittfogel here is that he illustrates the tendency to see the forms of irrigation organization as unavoidable, as generated and required by imperatives of the physical system and its technology.

There are perhaps two main reasons for this tendency. First, on all irrigation systems which are larger than "community" and in which water is controlled and allocated by a bureaucracy, that bureaucracy has to be fitted geographically to the permanent physical irrigation network. Certain tasks have to be carried out and staff are thought to be needed to perform them. Second, many statements about irrigation are based on detailed analysis of only one example, from which generalizations are extrapolated. The rather superficial information gathered in South India and Sri Lanka has provided an opportunity to see what variations in organization there may be over a wider range of examples than is usually available.

The outcome is surprising. It presents alternatives to the authoritarian, disciplinary, and totalitarian organizations postulated by Wittfogel, and shows considerable variance in the discretion of the bureaucracy on major irrigation. It is sobering to think how much simpler the conclusions might have been had only Sri Lanka's irrigation been considered. As it is, with the corrective of the system of community management under Dusi-Mamandur tank in Tamil Nadu, there seems nothing inevitable in the Sri Lanka pattern of a bureaucracy controlling issues down to the feeder level. The culture in which an irrigation system exists appears a major determinant of the form of organization: thus in the Sri Lanka examples, where the society is more egalitarian and more anarchic, bureaucracy extends farther down the physical system and the case for tighter bureaucratic controls seem clear; but in India, where the controls already exist in the hierarchical structure of the society, it has not been necessary for bureaucracy to extend so far down the system and the need for stricter bureaucratic controls is less obvious.

The technologies used for water acquisition, storage, and distribution, and for the maintenance of works, also underly the organization and political economy of irrigation. Direct individual appropriation from wells is sensitive to technology and an innovation like pump sets can radically differentiate access to water in a community and also deplete a communal resource. When larger-scale technology is used, there arise multifarious problems of allocation and appropriation, some of which have been discussed above. As Wittfogel argued, the requirements of construction and maintenance are powerful influences on social organization. Again, however, the technology used has a bearing. Wittfogel assumed that human labor was the main means used to build and maintain ancient irrigation works. It is at least possible that this was not the case with the ancient tanks of the dry zone of Sri Lanka, and that elephants were used as the bulldozers of that day. If so, then the form of organization may well have been closer to a modern PWD or military engineering unit than to a totalitarian bureaucracy exacting forced labor from peasants. Moreover, with present-day irrigation it is only at the lower levels, as at Dusi, Meppathurai, and Vinayagapuram, that communal labor and not machinery has to be mustered.

At a practical level, both organization and technology are manipulable and subject to choice. The objectives of irrigation can be variously stated, but in the conditions of South Asia a list might include:

productivity (of water)
equity (in its distribution to users)
stability (in maintaining the water supply over the years)
continuity (in water use throughout the year)
carrying capacity (in sustaining population at acceptable levels of living)

In achieving these objectives, and subject to trade-offs, the prescriptions vary by type of irrigation. For bureaucractic-communal and communal irrigation in the examples analyzed, the key lies in the reform of organization and operation—in short, in improved management of men. For direct-acquisition irrigation, the key lies in the design of appropriate technology for the acquisition process. In both organization and technology we are only at the beginning of appreciating the potential. In view of the rapidly increasing pressure of population on water supplies—especially in parts of India but elsewhere also—exploring and exploiting that potential is a high priority. On the organizational side it requires more and better research, especially by social scientists, combined with and supporting management consultancy and staff training. On the technological side it requires imaginative and vigorous research and development to create technologies appropriate for future rural life.

References

CHAMBERS, ROBERT. 1975a. *Water Management and Paddy Production in the Dry Zone of Sri Lanka*. Occasional Series no. 8, Agrarian Research and Training Institute, Colombo.

_____. 1975b. *Two Frontiers in Rural Management: Agricultural Extension and Managing the Exploitation of Communal Natural Resources*. Communication Series no. 113, Institute of Development Studies, University of Sussex.

_____. 1976. "On Substituting Political and Administrative Will for Foreign Exchange: The Potential of Water Management in the Dry Zone of Sri Lanka," in *Agriculture in the Economic Development of Sri Lanka*, ed. S. W. R. de A. Samarasinghe (Peradeniya: Ceylon Studies Seminar).

_____ and MORIS, JON, eds. 1973. *Mwea: An Irrigated Rice Settlement in Kenya*. Munich: Weltforum Verlag.

ELLMAN, A. O., and RATNAWEERA, D. de S. 1973. *Thannimurrippu Paripalana Sabai: The Transfer of Administration of an Irrigated Settlement Scheme from Government Officials to a People's Organisation*. Occasional Series no. 1, Agrarian Research and Training Institute, Colombo.

FARMER, B. H. 1957. *Pioneer Peasant Colonization in Ceylon*. London: Oxford University Press.

FERNEA, R. A. 1970. *Shaykh and Effendi: Changing Patterns of Authority among the El Shabana of Southern Iraq*. Cambridge: Harvard University Press.

German Foundation for Developing Countries. 1967. *Report on the Seminar on Economic and Social Aspects of Agricultural Development in Irrigated Areas*. Berlin: Reiher-Werder.

Government of India. 1973. *Interim Report on Modernising Irrigation Systems and Integrated Development of Commanded Areas*. New Delhi: National Committee for Agriculture.

HARRISS, J. C. 1976. *Aspects of Rural Society in the Dry Zone Relating to the Problem of Intensifying Paddy Production*, in *Agriculture in the Peasant Sector of Sri Lanka*, ed. S. W. R. de A. Samarasinghe. Peradeniya: Ceylon Studies Seminar.

ICAR. 1966. *Report of the Working Group for the Formulation of Fourth Five-Year Plan Proposals on Soil and Water Management under Irrigated Conditions*. New Delhi: Indian Council for Agricultural Research.

IRRI. 1973. *Water Management in Philippine Irrigation Systems: Research and Operations*. Los Baños: International Rice Research Institute.

LEACH, E. R. 1961. *Pul Eliya: A Village in Ceylon*. Cambridge: Cambridge University Press. [Chapter 5 in this volume.]

LEVINE, G.; CARPENER, H.; and GORE, P. 1973. *The Management of Irrigation Systems for the Farm*. Research and Training Network reprint no. 2. New York: Agricultural Development Council.

MADDUMA BANDARA, C. M. 1976. *The Prospects of Recycling Subsurface Water for Supplementary Irrigation in the Dry Zone*, in *Agriculture in the Peasant Sector of Sri Lanka*, ed. S. W. R. de A. Samarasinghe. Peradeniya: Ceylon Studies Seminar.

MIP. 1972. *Report of the Irrigation Commission, 1972*, vols. i–iii. New Delhi: Ministry of Irrigation and Power.

MPEA. 1968. *Report of the Irrigation Program Review—Ceylon*. FAO/IBRD Cooperative Programme, Ministry of Planning and Economic Affairs, Colombo.

ONGKINGCO, P. S. 1973. *Organization and Operation of 15 Communal Irrigation Systems in the Philippines*, in IRRI, 1973, pp. 235–42.

THORNTON, D. S. 1976. "The Organisation of Irrigated Areas," in *Policy and Practice in Rural Development*, ed. Guy Hunter, A. H. Bunting, and A. Bottrall. London: Croom Helm.

VANDER VELDE, E. J., JR. 1971. "The Distribution of Irrigation Benefits: A Study in Haryana, Inda," Ph.D thesis, University of Michigan. [Chapter 14 in this volume.]

WEERAKOON, B. 1973. *Role of Administrators in the Context of a Changing Agrarian Situation—A District Point of View*, Seminar on Economic and Social Consequences of the Improved Seeds, Kandy, mimeo.

WITTFOGEL, K. A. 1957. *Oriental Despotism*. New Haven: Yale University Press.